Design of A Solar Panel Diving Boat to Support Diving and Research Activities on The Small Islands

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Abstract. This study aims to design a solar panel boat with the most valuable functions and roles for diving and research activities. Furthermore, studies on its design and construction are often simulated in several stages, starting from data collection on the boat instrument, followed by an analysis of the model. The payload was then calculated using the long-term forecasting method by predicting the load of solar panels and primary equipment placed in the dive boat. The estimated speed and battery storage capacity were also assessed to obtain the principal dimensions. The design of this tourist diving boat used twin hulls (catamarans) to increase the ship's water draft. The deck of the vessel incorporated transparent glass, and it was equipped with safety equipment that allows passengers to observe coral reefs. The vessel has a height, width, and length of 0.665, 2, and 7 meters, respectively. It was also outfitted with a 20-horsepower electric engine capable of attaining a speed of 9 knots, which is suitable for sailing to ecotourism regions. Furthermore, a battery-operated device supplemented using a solar panel with a peak power output of 2,960 watts was installed.

Keywords: Boat, catamaran, ecotourism, renewable, solar.

1 Introduction

The construction of an effective, efficient, and appropriate ship is the primary foundation for maximizing the potential of marine resources and using maritime services [1] in an archipelagic country. Furthermore, the role of Naval Architecture is critical and essential in delivering and producing optimal products because the manufacturing process requires large capital [2,3]. Several studies also revealed that accidents [4,5], contamination of the marine environment [6,7], and unprofitable ships can lead to the loss of revenue [8].

The architecture and design of ships to be created in an archipelago country

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requires a lot of thorough and objective considerations, including selecting the type of function [9]. This selection process is critical because the product is expected to operate optimally as well as provide excellent responses and economic benefits based on the geographical characteristics of its area [10]. The categories of vessel functions that can be selected for construction vary. Furthermore, each of them has a specific purpose, such as small fishing vessels with limited operation [11]. The larger variant can operate on the sea, and it is equipped with facilities that freeze and capture fishery products (Fish Factory Vessel) [12].

The differences in the function of the type of ship and other essential characteristics are often included in the design planning to determine the shape of the hull. Most ships are designed with a single hull, while others, such as tankers [13] must have two to prevent accidents and corrosion. This indicates that the double type is the best option [14], but it causes the structure to be more unstable. Therefore, for some commercial ships, a double-hull design is not required [15]. The use of an airfoil is also one of the hull shape variations in recent design development, including being operated on a Wing in Ground ships [16–18]. Furthermore, the design analysis is not limited to different functions and forms, the structure of the vessel also influences the final design to be built. A weak and susceptible structure can cause accidents during operations [19], while the strong variant increases the weight, raises the draft, and increases costs, but the ship becomes safer and stronger. The most effective way to determine the structure of a ship is to use the correct components, namely steel, wood, aluminum, and fiber [20].

The Riau Archipelago is one of the largest in the archipelago, with an area of 8,201.72 km^2, which is almost 96 percent water and only 4 percent land. There are 2,408 large and small islands in the Riau Islands region, 30 percent unidentified and uninhabited. The Riau Islands region's potential provides advantages for marine ecotourism areas. The Riau Archipelago is also renowned for its coral reef ecosystems and associated marine biota and its exceptional underwater natural beauty for scuba divers. However, the use of non-environmentally friendly fossil fuels by tourist boats in the Riau Islands has persisted up to this point, resulting in the pollution of the coral reef ecosystem by the remaining burning oil from the ships. If the intensity of marine tourism activities that continue to use fossil fuels increases, coral reef ecosystems will deteriorate and perish over time. Additionally, other impacts of marine ecotourism that are produced will vanish. The use of solar-powered boats also positively affects society, as it reduces the burdensome dependence on fossil fuels. Thus, using solar boats and electric motors will become more cost-effective shortly.

2 Research Methodology

2.1 Determination of the ship payload

The payload must be determined using the long-term forecasting approach while establishing the primary size of the dive boat to be built [21,22]. The weight of the significant equipment installed can be used to determine the primary size. In this study, the payload of each equipment and the quantity in the dive boat was calculated. The following data were collected from the Oceanographic Laboratory of the Faculty of Marine and Fisheries Sciences and the Diving Laboratory of the Faculty of Marine and Fisheries Sciences: 1) Scuba diving apparatus, including dive tank & valve, BCD, Regulator, Gauge console, and Scuba Accessories; 2) Fundamental diving equipment, such as diving mask, snorkel, wetsuit, booties, and open heel fins; 3) Water quality testing equipment, namely multi water parameters, turbidity meter, Secchi disk, refractometer, as well as pH and DO meter; 4) Oceanographic instruments, such as tide master, current meter, ADCP, and CTD; and 5) Sonar transmission apparatus, namely Echosounder. The weight and quantity of each of the equipment were obtained, and it was added to the estimated man on board for diving boat operations to obtain the total payload weight.

2.2 Calculating Ship Displacement

Ship displacement is an important factor, which is often considered in the design. The tons of water displaced by the submerged portion on the sea surface is generally measured in metric tons. Displacement, commonly known as the ship's submerged weight, is influenced by the specific gravity of the water, which is affected by the temperature of the water body. Furthermore, it is divided into 2 categories during the design process, namely light and loaded displacement [23,24].

2.3 Calculating the primary dimension of the research vessel

The ship's principal dimension is critical for design, as various crucial ship parameters must be specified accurately [25]. The Ship's Main Dimensions (Principal Dimensions) describe the overall size of the ship's hull, which includes the ship's length, width, and height [26]. These three dimensions are critical in determining the ship's capacity and other characteristics linked to shipping stability [27]. The primary size impacts the worth or price of the size of the ship's body. For example, the price of a ship with the same tonnage is decided by its primary size. The primary size of the ship also has a significant impact on the ship's capabilities, including 1) Ship space calculation based on ship length and stability; 2) Determination of the ship's breadth concerning its thrust; 3) The ship's height is intimately related to the storage of products and the location of the ship's center of gravity.

3 Result and Discussion

3.1 Determination of the ship payload

The payload is the amount of cargo or passengers a ship can convey, and it is often increased to a feasible point to maximize profit. It is also an instrumentation tool used in study activities and various equipment that are permanently mounted on the ship to construct boats. The instruments used to determine the cargo of a solar-powered tourist ship include lightship, solar panel, and Superstructure.

Table 1. Equipment List for determining payload on Solar panel Boat

Types of Research Equipment	Equipment list	Function
Oceanography Equipment	Mini CTD (Conductivity Temperature Depth)	measure the salinity of seawater, temperature, and depth at the desired place and depth.
	Acoustic Doppler Current Profiler	measuring suspended sediment content based on acoustic backscatter value.
	Light Autonomous Underwater Vehicle	method for mapping the seafloor substrate.
	Eckman Grab	As a collection of sediment samples
	Echo sounder	A method for mapping the seafloor substrate is to locate items such as schools of fish and bubble columns coming from the seafloor a method for mapping the seafloor.
	Fish Finder	measure the depth of the water
	Multi-water Parameter	measure water quality, and one must monitor oxidation and oxygen levels in the water.
	Turbidity meter	ensure that the water used is high quality, based on its turbidity level.
	Tide master	To be aware of the state of the tides
Dive Equipment	Dive Tank	provides undersea breathing gas at high pressure.
	Regulator	Delivers pressurized breathing gas at ambient pressure to the diver
	Compressor	A gas compressor that may give breathing air directly to a surface-supplied diver or fill diving cylinders with high-pressure
	Open Heel	permit divers to move through the water with relative ease.
	Dive Mask	A piece of diving equipment helps underwater divers see clearly, including scuba divers, free-divers, and snorkelers.
	Booties	Warm diver ankles, feet, and toes in and out of the water.
	Gauge Console	Incorporating a pressure gauge, depth gauge, and compass into a single console is essential for diving safety.
	Wetsuit	conserve body heat

3.2 Analysis of Lines Plan, General Arrangement, and Stability

According to our research findings, the design of this tourist boat uses twin hulls (catamarans) by considering the area that can be used to accommodate tourists in exploring ecotourism areas on the island of Bintan, which is also equipped with safety equipment and glass. Furthermore, the boat deck is translucent, allowing one to observe the coral reefs without swimming in the sea. This ship is 7 meters in length, 2 meters in width, and 0.665 meters in height. Furthermore, this ship has a 20 hp electric engine capable of achieving a speed of 9 knots, which is sufficient for mobilization in tourist zones. According to the research findings, the design of this tourist ship will position the solar panel load on the roof of the tourist ship to increase the number of solar panels that can be installed on a solar panel-based tourist ship. Based on the outcomes of the general layout drawing. The individuals on the ship will be divided into two sections to increase its stability when the number of passengers reaches its maximum capacity. The middle chamber of the solar-powered tourist boat is large enough to accommodate diving equipment and research items. The diagram below depicts the main layout of a solar-powered tourist cruise.

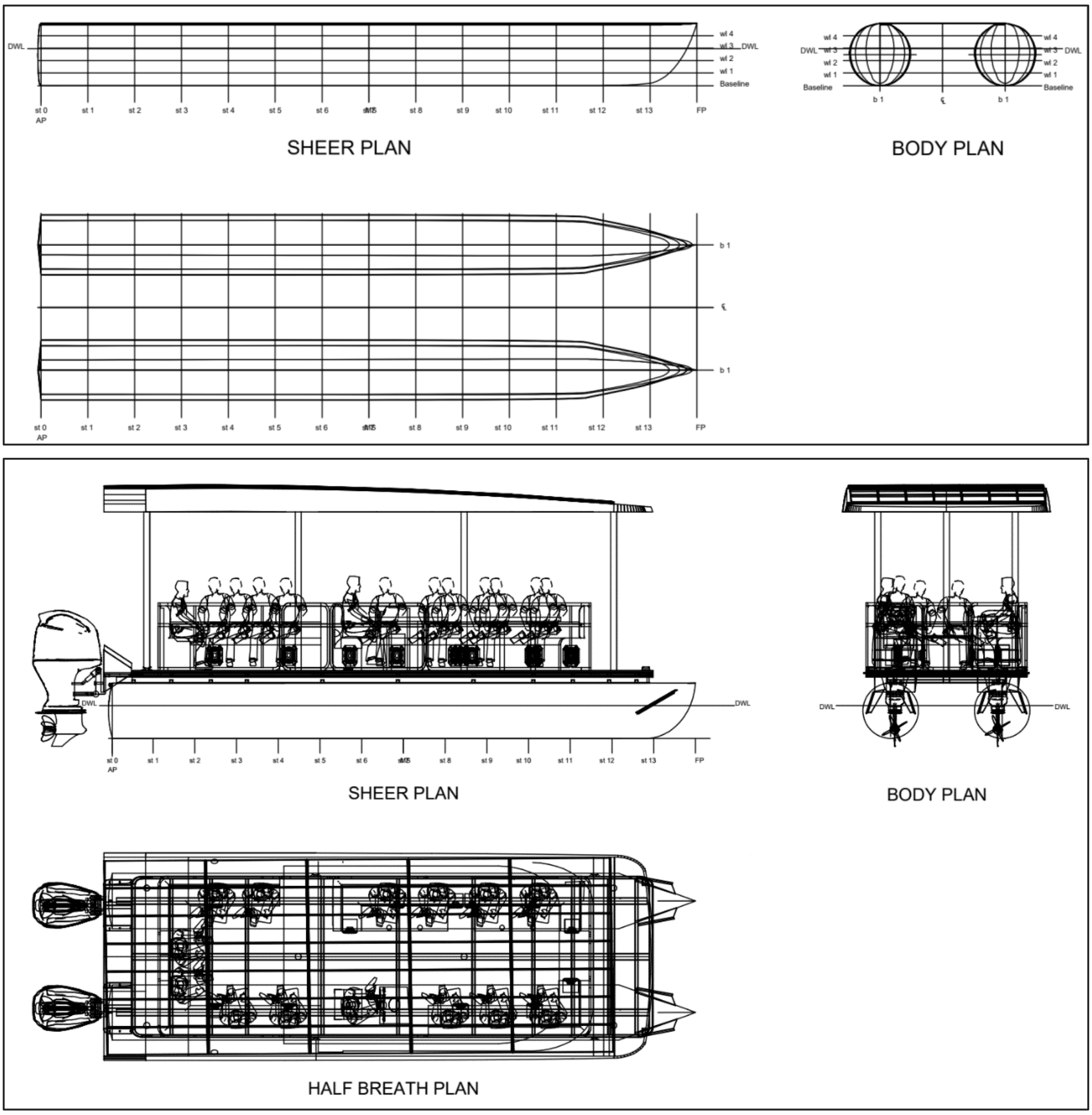

Figure 1. Solar panel-based ship lines plan (top) and general arrangement (bottom)

The design analysis of the primary dimensions of the solar boat yielded the following results: Length Over All (LoA) of 7,033 meters, Length of Water Line (LWL) of 6,926 meters, Beam Mld of 1,986 meters, Depth Mld of 0,662 meters, and designed draft of 0,394 meters (Figure 1). The solar boat design has a total mass of 3,369 tons. From the dimension area of the solar panel, this boat has a 20-horsepower electric motor capable of reaching a speed of 9 knots, making it perfect for deploying this vessel in areas that are popular for ecotourism due to the accessibility it provides to these areas. In addition, there is a gadget powered by batteries and augmented by a solar panel with a peak power output of 2960 watts.

Table 2. Stability Analysis of Solar Panel Boat

Item Name	Quantity	Unit Mass Tonne	Total Mass Tonne	Unit Volume m^3	Total Volume m^3	Long Arm m	Trans. Arm m	Ver. Arm M	Total FSM Tonne.m
Lightship	1	2.699	2.699	-	-	3.143	0.000	0.343	0.000
Solar panel	1	0.170	0.170	-	-	3.500	0.000	2.661	0.000
Superstructure	1	0.500	0.500	-	-	3.200	0.000	1.000	0.000
Total Load case	-	-	3.369	0.000	0.000	3.169	0.000	0.557	0.000
FS Correction	-	-	-	-	-	-	0.000	-	-
VCG Fluid	-	-	-	-	-	-	0.557	-	-

The stability analysis results, as indicated in Table 2, using a specific gravity of 1.025 (density 1.025 tons/m^3) shows that the lightship, solar panel, and Superstructure have weights of 2.69 tons, 0.17 tons, and 0.500 tons, respectively. The lightship, solar panel, and Superstructure have horizontal and vertical arms of 3.143 m, 3.500 m, 3.200 m; and 0.343 m, 2.661 m, 1 m, respectively. The FC correction value was 0, and VCG Fluid was 0.557.

3.3 Discussion

A catamaran is a ship with two similar hulls connected by a central bridge framework. Furthermore, it has relatively strong stability due to the shape of the hulls. The ship's surface area immersed in water is relatively small, which causes a short draft for the vessel. The catamaran has a fragile water line, where the hull touches the water to attain little resistance. The height of the waves encountered throughout the shipping route has an essential role in establishing the distance between the water's surface and the structure at the top of the hull. This ship is also reliable for moving freight between cities and tourism due to its large deck space and low weight when it is empty.

The catamaran has several advantages and disadvantages in critical areas compared to the monohull vessels [28]. Based on previous studies, catamarans with the same breadth have lower frictional resistance [29], which indicates that they have a higher speed at the same thrust. Furthermore, the deck area is more significant compared to that of the monohull. The submerged volume of the ship and the surface area have low wetness and it has better stability due to the presence of two hulls with low resistance. It also has a low operational costs, and the image impressed is the ship's guaranteed safety.

One advantage of catamarans when sailing is that they can overcome problems caused by wave conditions and the force of the wave currents [30]. Furthermore, when it comes to shipping stability research, catamarans have the advantage of being more stable than other types of sailboats. Catamarans have various advantages when used as fishing boats, including the fact that the powerful engine employed is around 45 percent smaller, they save up to 40 percent of their fuel, and it is simple to use a sail as a source of propulsion. This is due to the ship's deck expanding, which does not interfere with any activities and results in a minor tilt angle [31].

This solar boat with solar panels is a catamaran-shaped vessel with a glass hull on the floor. The contribution of this study is the design of ships that are environmentally friendly and functional for ecotourism. The construction of a glass hull on the ship's floor is the most recent innovation for tourist boats. The glass hull on the floor allows travelers to view the Bintan coral habitat without needing to snorkel or dive.

4 Conclusion

The estimate of the speed of the ship and its capacity for battery storage was calculated to obtain the principal dimensions. Furthermore, the design of this tourist diving boat integrates two hulls (catamarans) by considering the area aspect that can accommodate tourists while exploring ecotourism regions on small islands. The deck of the vessel also incorporates transparent glass, and is equipped with safety equipment that allows passengers to observe coral reefs. The vessel has a height, width, and length of 0.665, 2, and 7 meters, respectively. It was also outfitted with a 20-horsepower electric engine capable of attaining a speed of 9 knots, which is suitable for sailing to ecotourism regions. A battery-operated device supplemented by a solar panel with a peak power output of 2,960 watts was installed on the vessel.

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